TRAC-MONTEREY

High Level Architecture (HLA) Dynamic Scenario Builder (DSB)

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U.S. ARMY TRADOC ANALYSIS CENTER-MONTEREY
TECHNICAL REPORT No. 99-03

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The sponsor for this project is U.S. Army Simulation Training and Instrumentation Command (STRICOM).

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	30 November 1999	Final Report/ May 1999 – November 1999)

4. TITLE AND SUBTITLE
High Level Architecture (HLA) Dynamic Scenario Builder (DSB) (Final Report)

5. FUNDING NUMBERS
None

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Postgraduate School
Monterey, CA 93943-5000

8. PERFORMING ORGANIZATION REPORT NUMBER
TRAC-MTRY-00-14

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
TRADOC Analysis Center – Monterey
Monterey, CA 93943-0692

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
None

11. SUPPLEMENTARY NOTES
None

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release, distribution is unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)
The HLA Dynamic Scenario Builder (DSB) initiative focused on improving the timeliness, quality, and cost-effectiveness of developing scenarios (and associated tools) for HLA simulations by standardizing the interchange of scenario data. This standardization effort was supported by reviewing legacy simulation scenario data, defining an HLA scenario logical data model, developing an XML Data Interchange Format (DIF) for exchanging scenario data, and specifying common requirements for compliant tools.

14. SUBJECT TERMS
Dynamic Scenario Builder (DSB), High Level Architecture (HLA)

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

ACKNOWLEDGMENTS

The U.S. Army Simulation Training and Instrumentation Command (STRICOM) supported the HLA DSB research. The authors thank the following individuals for their advice and contributions: Dr. Mona Crissey of STRICOM and Jack Sheehan of the Defense Modeling and Simulation Office.

NOTICES

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Destroy in accordance with the procedures in DOD 5200.22-M, Industrial Security Manual, Section 11-19 or DOD 5200.1-R, Information Security Program Regulation, Chapter IX.

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High Level Architecture (HLA) Dynamic Scenario Builder (DSB)

(Final Report)

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ABSTRACT

The HLA Dynamic Scenario Builder (DSB) initiative focused on improving the timeliness, quality, and cost-effectiveness of developing scenarios (and associated tools) for HLA simulations by standardizing the interchange of scenario data. This standardization effort was supported by reviewing legacy simulation scenario data, defining an HLA scenario logical data model, developing an XML Data Interchange Format (DIF) for exchanging scenario data, and specifying common requirements for compliant tools.

EXECUTIVE SUMMARY

Simulation systems would operate more effectively if they shared scenario data. Scenario data could be shared between scenario generation systems prior to initialization to facilitate interoperability during runtime execution. Additionally, scenario developers could reuse scenario contents from other simulation systems if they were able to access the other systems' scenario data. The task of developing scenario-related tools would be simplified if scenario data was available in a standardized format. However, most simulations were developed in a 'stove-piped' manner that precludes the simple reuse of scenario data between simulations. Sharing scenario data currently requires 'point to point' interfaces that are expensive to develop and maintain. This problem has led to the current research into interchanging scenario data.

The High Level Architecture (HLA) Dynamic Scenario Builder (DSB) initiative focused on improving the timeliness, quality, and cost-effectiveness of developing scenarios (and associated tools) for HLA simulations by standardizing the interchange of scenario data. The standardization process consisted of reviewing legacy simulation scenario data, defining an HLA scenario logical data model, developing an XML Data Interchange Format (DIF) for exchanging scenario data, and specifying common requirements for compliant systems.

1. INTRODUCTION

The High Level Architecture (HLA) Dynamic Scenario Builder (DSB) research addresses the problem of interchanging scenario data. The effort documented in this report leverages prior scenario data interchange research and begins to achieve the long-term goals the HLA DSB initiative.

1.1. Problem Description

Scenario development is a critical step in the development of an HLA simulation. The process of developing and executing an HLA federation is formalized in the Federation Development and Execution Process (FEDEP) model [1]. The interfaces between tools supporting the FEDEP are defined in the HLA Tool Architecture [2]. Data Interchange Formats (DIFs) have been defined to support many of these interfaces. However, a “scenario DIF” has not yet been defined.

HLA federation scenarios could be developed and executed more effectively if federates shared scenario data prior to initialization. Scenario developers rarely reuse scenarios from other simulation systems because they cannot access other systems’ scenario data. Scenario-related tool development is a complex task partly because new formats are typically generated for each new system. Most simulations are built in a “stove-piped” manner that precludes simple reuse of scenario data between simulations. Sharing scenario data usually requires “point to point” interfaces that are expensive to develop and maintain.

1.2. Background

The USMA previously conducted related research demonstrating the ability to retrieve and view legacy scenario data [4]. The project utilized database mediation technology [5]. Specifically, USMA used the HERMES tool [6] to demonstrate how mediation rules can drive the access of files. Concepts for HLA-related data interoperability in general [7] and scenario data specifically [8] have been presented at numerous modeling and simulation conferences. Results from these efforts were used in the research described in this paper.

1.3. Objectives

In order to focus current and future scenario interoperability efforts, the HLA DSB development team identified a set of long-term objectives. The research vision is to improve the timeliness, quality, and cost-effectiveness of developing scenarios (and associated tools) for HLA simulations by standardizing the interchange of scenario data. The vision supports both scenario tool developers and scenario developers. However, the ultimate beneficiaries are the sponsors that fund HLA federations.

The following goals benefit HLA scenario-related tool developers:

- Reduce the time and cost to develop interoperable HLA scenario-related tools.
- Improve the quality of HLA scenario-related tools.

The following goals benefit HLA scenario developers:

- Reduce the time and cost of developing HLA scenarios.
- Improve the quality of HLA scenarios.

The HLA DSB initiative will achieve the goals described above by providing the following mechanisms. The following mechanisms support tool development.

- Provide an open standard to support making HLA scenario-related tools interoperable,
- Maximize the potential use of Commercial-Off-The-Shelf (COTS) technology to support the development of scenario-related tools,
- Facilitate the reuse of HLA scenario-related tool components , and
- Minimize the impact of scenario data content and format changes on tool software.

The following mechanisms support scenario development:

- Maximize the amount of HLA scenario data that a scenario developer can reuse from existing scenarios, and
- Support development of HLA scenarios as part of DoD simulation and training development processes (e.g., Joint Training System, HLA FEDEP).

The approach to developing the mechanisms described above will be supported by the following goals:

- Guide tool developers by expanding the HLA tool architecture to include a scenario development tool architecture,
- Develop standards for tool developers that comply with DoD interoperability and data standards,
- Support web-based scenario-related tools,
- Provide sample code and sample data to support HLA tool developers, and
- Support scenario repository use by scenario developers.

Achieving the goals listed above will satisfy the HLA DSB long-range vision. Details of the HLA DSB objectives formulation activity were provided in the Objectives Statement report [8].

2. HLA DSB INITIATIVE

The HLA DSB initiative focused on improving the timeliness, quality, and cost-effectiveness of developing scenarios (and associated tools) for HLA simulations by standardizing the interchange of scenario data. The standardization effort began by reviewing legacy simulation scenario data and defining an HLA scenario logical data model. Next, the investigators developed an eXtensible Markup Language (XML) Data Interchange Format (DIF) for exchanging scenario data and developed common software requirements for HLA DSB compliant systems [9].

2.1. Legacy Scenario Data Analysis

The investigators reviewed existing (legacy) scenario data models to identify common scenario data elements. The review focused initially on constructive training simulations.

Candidate legacy simulation systems (e.g. Janus, ModSAF) were ranked according to their relevance to the HLA DSB objectives. The following relevance categories (in order of decreasing priority) were identified:

- Constructive Simulation Object Models,
- Non-constructive Simulation Object Models,
- Simulation related Object Models, and
- Non-simulation Object Models.

Constructive simulations were highest priority because they were the initial focus of the DSB initiative. Non-constructive simulations (e.g. virtual simulation CCTT) were not as relevant but still high priority. Simulation-related items included data interchange formats (e.g. Unit Order of Battle (UOB) DIF) that were relevant, but did not support a particular simulation.

As information on scenario data models was gathered, a wide variety of representation formats were encountered. Each data source was logged and added to the project library. Entity data is closely associated with the concept of a 'class' in object-oriented technology. An entity includes attributes that can be sub-entities or variables of a particular datatype. The entity level was selected for extraction of key organizing principles for scenario descriptions.

The analysis focused on the 'problem domain' portion of scenarios. The problem domain is the description of the 'real world' being simulated. The 'solution domain' includes information on 'how' a scenario will be supported. Data needed to initialize a simulation with 'real world' information was also given high priority.

Investigators developed a database in Microsoft Access to store entity descriptions. The schema for the database was based on the identified fields in the DoD's Data Standardization Procedures [10] for representing metadata.

Upon review of the database of legacy data model entities, categories were established for grouping purposes. These categories were somewhat arbitrary and not meant to suggest the structure of the next phase's logical data model.

The categories identified were:

- Unassigned,
- Metadata,
- Environment,
- Organization,
- Simulation Object,
- Information Item, and
- Events.

A final category, ‘Out of Scope’ was added to define legacy data model entities that did not fall within the scope of our scenario definition. Legacy data entities were assigned to appropriate groups (see Figure 1).

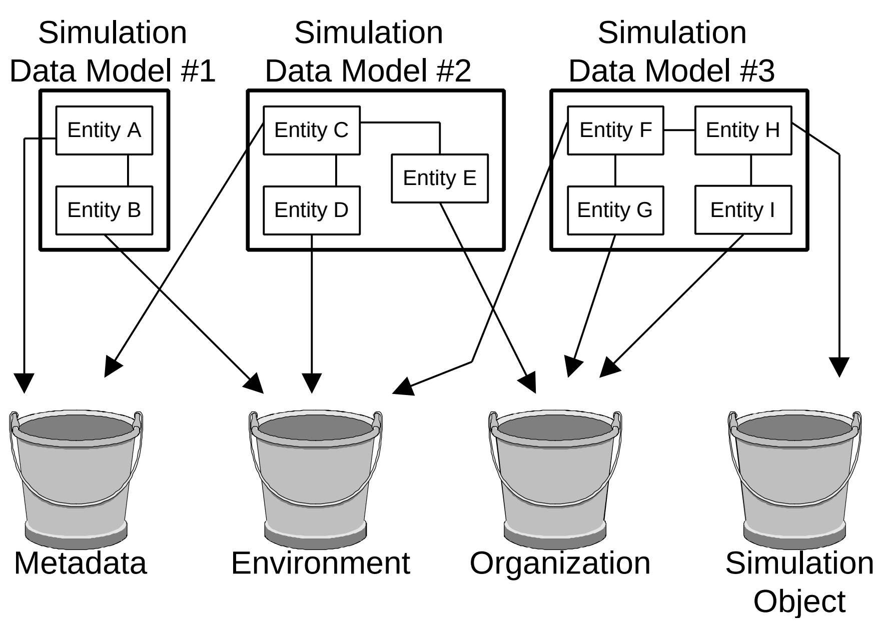

Figure 1. Assigning Entities to Categories

Details of the HLA DSB scenario legacy analysis are provided in a Legacy Scenario Analysis report [11].

2.2. Logical Data Model

A logical data model was developed to describe the scenario standard. The data model is intended to be a first description that will evolve as research continues.

The challenge was to develop a data model that supported many disparate simulations, provided flexibility in providing coverage for all legacy elements, and provided a useful structure. At one extreme, the data model could have been a compilation of all legacy systems. However, that approach would have required updates every time a new simulation is developed. Alternatively, at the other extreme, the data model could have been a "metamodel" that approached the simplicity of a Computer Aided Software Engineering (CASE) tool model that simply identified the existence of entities and attributes.

A compromise approach was taken that provides common scenario concepts as organizing principles, but includes the concept of "Property" classes that associate any type of value with a scenario component. The development of the data model began with an Entity Relationship Diagram (ERD). The ERD borrowed heavily from the categories identified in the legacy data analysis. The ERD was then evolved into an Integration Definition Language for Information Modeling Version 1X (IDEF1X) data model diagram (see Figure 2). IDEF1X is the preferred language for representing data models [12]. A data dictionary was developed detailing the entities and attributes of the data model.

To verify the data model coverage, a mapping was created to ensure that all legacy scenario data model entities could be assigned to an entity in the HLA DSB data model. Details of the HLA DSB mechanism design effort are detailed in a Legacy Data Model report [13].

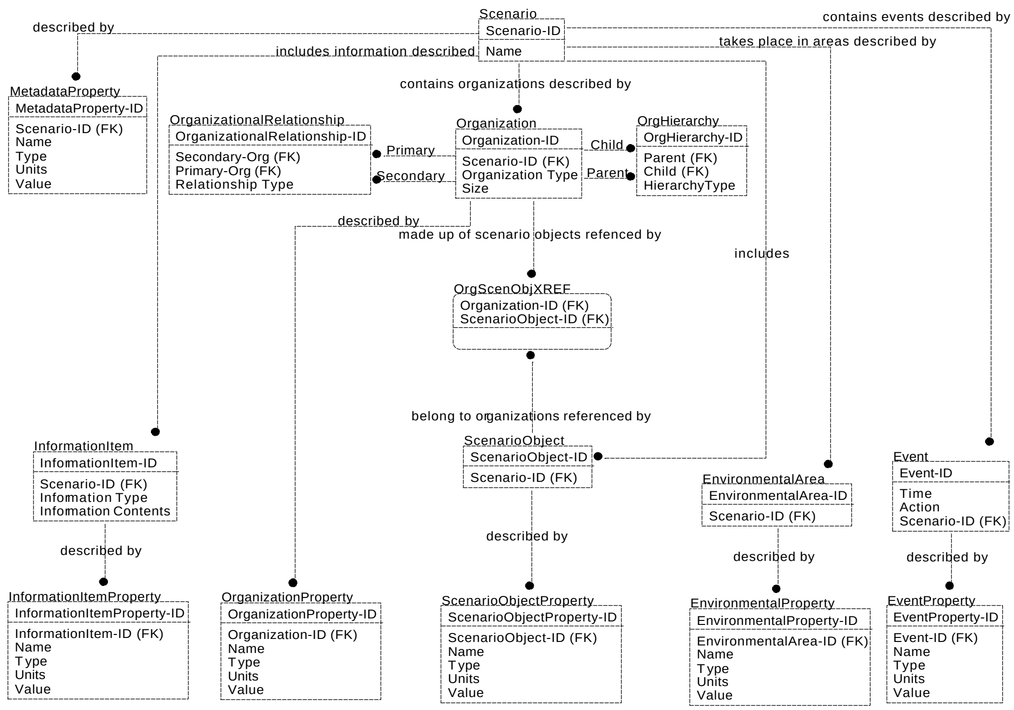

Figure 2. HLA DSB Data Model

2.3. XML Data Interchange Format

XML was selected as the method for describing the data interchange for the scenario data. XML is a metalanguage – a language for describing languages [14]. XML languages use markup similar to the web's Hypertext Markup Language (HTML). XML has been recommended for interchanging simulation data [7] and for maintaining metadata for HLA-related repositories. [15]

An XML format is described in a Document Type Description (DTD). The first step in defining the HLA DSB DTD was to evolve the logical data model into a 'tree structure'. XML DTDs are inherently tree based. The HLA DSB tree data structure is provided in Figure 3. The '?' is used to identify optional items. The '*' is used to identify 0 or more occurrences. An XML DTD for scenarios has been developed based on the data model described above and are provided as Appendix A.

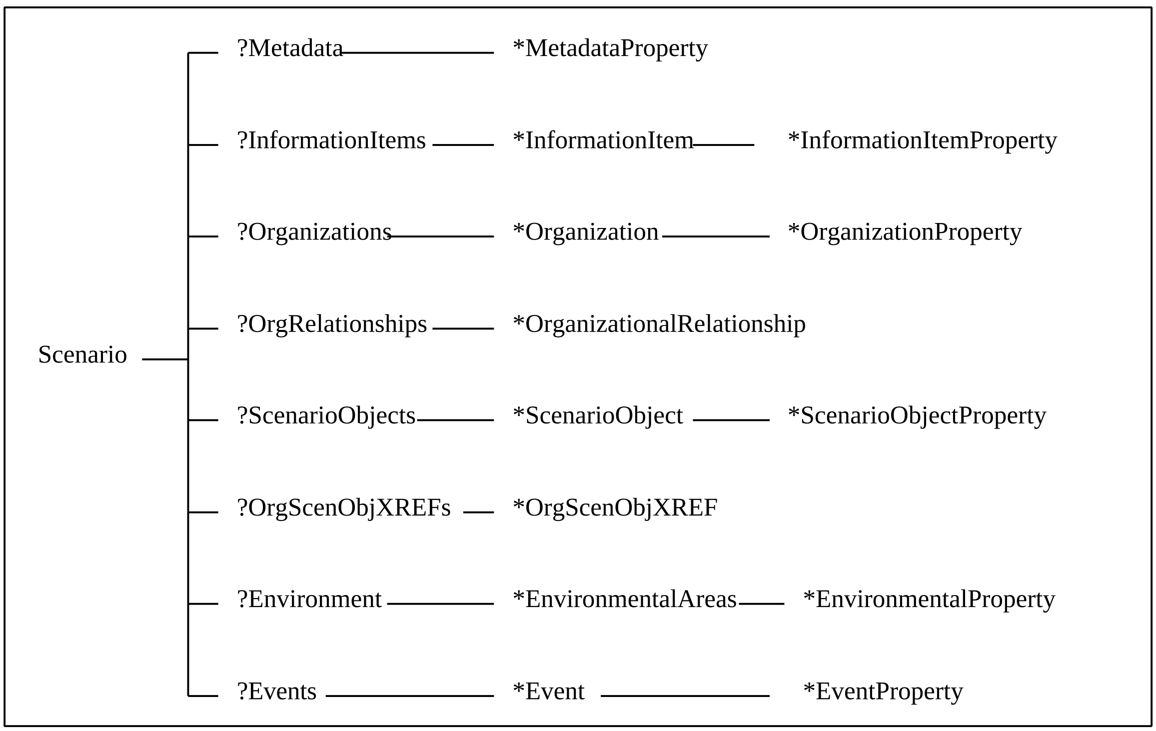

Figure 3. HLA DSB XML DTD Tree View

An example of a portion of data represented according to the DTD is provided in Figure 4.

```
<organization type="Armor" size="4">
<organizationproperty name="Organization Name" Type="String" Units="N/A">AR 5-11 Co
A</organizationproperty>
</organization>

<scenarioobject>
<scenarioobjectproperty name="Bumper Number" Type="String" Units="N/A">A11</
scenarioobjectproperty >
<scenarioobjectproperty name="Object Type" Type="String" Units="N/A">M1A1 MBT</
scenarioobjectproperty>
</scenarioobject>
```


Figure 4. Sample Scenario Data in XML

The primary advantage of XML representation is the ability to leverage commercial off-the-shelf (COTS) XML-enabled applications and code libraries. For example, a Microsoft Visual Basic application can parse an XML file into memory with a single line of code. Details of the development of the HLA DSB mechanism are provided in the Mechanism report [16].

2.4. Common Software Requirements

A variety of HLA DSB compliant systems may be built in the future. Although each application may have unique requirements, they will likely share certain features that make them HLA DSB compliant.

A set of common software requirements has been specified to support development of application requirements. These requirements involve the creation, retrieval, update, deletion, import, and export of scenario data that conform to the HLA DSB standard. Details on the development of common requirements are found in the Mechanism Requirement report [17].

3. FUTURE DIRECTION

The standards developed under the current HLA DSB effort can be used to support new and existing simulation applications. Figure 4. displays an operational concept of HLA DSB related tools and data.

COTS support for XML continues to evolve at a rapid pace. Microsoft and Netscape browsers have built-in support for browsing XML data files. Many database vendors are beginning to provide XML views on their data. Many application development tools (e.g. Microsoft's Visual Basic) now support XML and the XML Document Object Model (DOM).

Industry acceptance of XML validates the choice of XML. However, extensions to the standard, and related standards (e.g. eXtensible Style Language) should be monitored for their applicability to scenario data interchange. The XML Data Schema initiative should be considered for representing the XML format in addition to a DTD. Data Schemas provide information on the relationship between entities and the specific data types of data elements.

Concepts developed as part of this research should be demonstrated. Legacy scenario data could be represented in XML and shared with prototype HLA DSB compliant tools.

Additional applications of XML for data interchange should be considered. For example, XML could be used to represent behavior data supporting Computer Generated Forces (CGF) [18].

4. CONCLUSION

Simulation systems would operate more effectively if they shared scenario data. Scenario data could be shared between scenario generation systems prior to initialization to facilitate interoperability during runtime execution. Additionally, scenario developers could reuse scenario contents from other simulation systems if they were able to access the other systems' scenario data. The task of developing scenario-related tools would be simplified if scenario data was available in a standardized format. However, most simulations were developed in a 'stove-piped' manner that precludes the simple reuse of scenario data between simulations. Sharing scenario data currently requires 'point to point' interfaces that are expensive to develop and maintain. This problem has led to the current research into interchanging scenario data.

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APPENDIX - HLA DSB XML DTD

The following XML DTD supports the HLA DSB standards.

```
<!--Scenario is the root element -->
<!ELEMENT Scenario (
    Metadata,
    InformationItem*,
    Organizations,
    OrganizationalRelationship*,
    ScenarioObjects,
    OrgScenObjXREFs,
    EnvironmentalArea*,
    Event*)>

<!-- The Metadata is a list of MetadataProperty elements -->
<!ELEMENT Metadata (MetadataProperty*)>

<!-- The MetadataProperty element is used -->
<!--to provide information about the scenario -->
<!ELEMENT MetadataProperty (#PCDATA)>
<!ATTLIST MetadataProperty Name CDATA #REQUIRED
    Type CDATA #IMPLIED
    Units CDATA #IMPLIED>

<!--InformationItem elements are used to describe -->
<!--pieces of information in the scenario -->
<!ELEMENT InformationItem (#PCDATA)>
<!ATTLIST InformationItem InformationType CDATA #IMPLIED>

<!-- The InformationItemProperty element is used -->
<!--to provide information about InformationItem elements -->
<!ELEMENT InformationItemProperty (#PCDATA)>
<!ATTLIST InformationItemProperty Name CDATA #REQUIRED
    Type CDATA #IMPLIED
    Units CDATA #IMPLIED>

<!-- The Organization element is used -->
<!--to provide information about the units and other -->
<!-- types of organizations within a scenario -->
<!--a unique identifier must be associated with an organization -->
<!--in order to reference it in relationships to scenario objects -->
<!--and other organizations -->
<!ELEMENT Organizations (Organization*)>
<!ELEMENT Organization (OrganizationProperty*, Organization*)>
<!ATTLIST Organization UniqueIdentifier ID #REQUIRED
    OrganizationType CDATA #IMPLIED
    Size CDATA #IMPLIED>

<!-- The OrganizationProperty element is used -->
<!--to provide information about an organization -->
<!ELEMENT OrganizationProperty (#PCDATA)>
<!ATTLIST OrganizationProperty Name CDATA #REQUIRED
    Type CDATA #IMPLIED
    Units CDATA #IMPLIED>

<!-- The OrganizationRelationship element is used -->
<!--to provide information about relationships between -->
<!-- organizations within a scenario -->
```

```
<!ELEMENT OrganizationalRelationship (PrimaryOrg, SecondaryOrg)>
<!ATTLIST OrganizationalRelationship RelationshipType CDATA  #IMPLIED>
<!ELEMENT PrimaryOrg (IDREF)>
<!ELEMENT SeondaryOrg (IDREF)>

<!--ScenarioObject elements are used to describe -->
<!--individual items in the scenario -->
<!--a unique identifier must be associated with a scenario object -->
<!--in order to reference it in mappings to organizations -->
<!ELEMENT ScenarioObjects (ScenarioObject*)>
<!ELEMENT ScenarioObject (ScenarioObjectProperty*)>
<!ATTLIST ScenarioObject UniqueIdentifier ID #REQUIRED
ObjectType CDATA #IMPLIED>

<!-- The ScenarioObjectProperty element is used -->
<!--to provide information about ScenarioObject elements -->
<!ELEMENT ScenarioObjectProperty (#PCDATA)>
<!ATTLIST ScenarioObjectProperty Name CDATA #REQUIRED
    Type CDATA #IMPLIED
    Units CDATA #IMPLIED>

<!-- The OrgScenObjXREF element is used -->
<!--to provide mappings between organizations -->
<!--and entities -->
<!ELEMENT OrgScenObjXREFs (OrgScenObjXREF*)>
<!ELEMENT OrgScenObjXREF (OrganizationID, ScenarioObjectID)>
<!ELEMENT OrganizationID (#PCDATA)>
<!ELEMENT ScenarioObjectID (#PCDATA)>

<!-- The EnvironmentalArea element is used -->
<!--to provide information about the bounded areas -->
<!ELEMENT EnvironmentalArea (EnvironmentalProperty*)>

<!-- The EnvironmentalProperty element is used -->
<!--to provide information about EnvironmentalArea elements -->
<!ELEMENT EnvironmentalProperty (#PCDATA)>
<!ATTLIST EnvironmentalProperty Name CDATA #REQUIRED
    Type CDATA #IMPLIED
    Units CDATA #IMPLIED>

<!-- The Event element is used -->
<!--to provide information about something -->
<!--that happens at a particular time -->
<!ELEMENT Event (Time, Action, EventProperty*)>
<!ELEMENT Time (#PCDATA)>
<!ELEMENT Action (#PCDATA)>

<!-- The EventProperty element is used -->
<!--to provide information about Event elements -->
<!ELEMENT EventProperty (#PCDATA)>
<!ATTLIST EventProperty Name CDATA #REQUIRED
    Type CDATA #IMPLIED
    Units CDATA #IMPLIED>
```